What is claimed is:

1. A method for use in a transmitter adapted to employ four transmit elements to transmit a source bit stream, the method comprising the steps of:

dividing said source bit stream into L data substreams, $L > 2$; and

grouping derivatives of symbols derived from each of said data substreams to form four transmit time sequences, one sequence for each transmit element, each of said time sequences spanning L symbol periods, at least one of said derivatives of said symbols being a complex conjugate of one of said symbols.

2. The invention as defined in claim 1 wherein L=4 and said time sequences are arranged according to a matrix, each time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as one of the matrices of the set of matrices consisting of

$$\begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ b_2 & -b_1^* & -b_4 & b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ b_4 & -b_3^* & b_2 & -b_1^* \end{bmatrix}, \begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ -b_2 & b_1^* & b_4 & -b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ -b_4 & b_3^* & -b_2 & b_1^* \end{bmatrix}, \begin{bmatrix} b_1 & -b_2 & b_3 & -b_4 \\ b_2^* & b_1^* & b_4^* & b_3^* \\ b_3 & b_4 & -b_1 & -b_2 \\ b_4^* & -b_3^* & -b_2^* & b_1^* \end{bmatrix}, \text{ and}$$

$$\begin{bmatrix} b_1 & b_2 & b_3 & b_4 \\ b_2^* & -b_1^* & b_4^* & -b_3^* \\ b_3 & -b_4 & -b_1 & b_2 \\ b_4^* & b_3^* & -b_2^* & -b_1^* \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively, and

* indicates complex conjugate.

3. The invention as defined in claim 1 wherein at least one of said groups of derivatives of said symbols includes derivatives of symbols from more than one of said data substreams.

4. The invention as defined in claim 1 further comprising the step of repeating said dividing and grouping steps.

5. The invention as defined in claim 1 wherein at least one of said derivatives of said symbols is one of the group consisting of: a negative of one of said symbols, a negative of a complex conjugate of one of said symbols, one of said symbols, a symbol developed by encoding at least one sample of at least one of said data substreams, an unencoded sample of at least one of said data substreams.

6. The invention as defined in claim 1 wherein each row of said matrix represents what is transmitted by a respective one of said transmit elements.

7. The invention as defined in claim 1 wherein at least one of said transmit elements is an antenna.

8. The invention as defined in claim 1 wherein L=4 and said time sequences are spread and arranged according to a matrix, each spread time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as follows:

$$\begin{bmatrix} b_1\overline{c}_1 & b_2^*\overline{c}_2 & b_3\overline{c}_3 & b_4^*\overline{c}_4 \\ b_2\overline{c}_1 & -b_1^*\overline{c}_2 & -b_4\overline{c}_3 & b_3^*\overline{c}_4 \\ b_3\overline{c}_1 & b_4^*\overline{c}_2 & -b_1\overline{c}_3 & -b_2^*\overline{c}_4 \\ b_4\overline{c}_1 & -b_3^*\overline{c}_2 & b_2\overline{c}_3 & -b_1^*\overline{c}_4 \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively;

* indicates complex conjugate; and

$\overline{c}_l$, l=1 .., L are each horizontal vectors of a spreading code, each of said horizontal vectors spans 1 symbol period and contains N chips, where N is the spreading gain.

9. A transmitter adapted for use with four transmit elements to transmit a source bit stream, comprising:

means for dividing said source bit stream into L data substreams, $L > 2$;

means grouping derivatives of symbols derived from each of said data substreams to form four transmit time sequences, each of said time sequences spanning L symbol periods, at least one of said derivatives of said symbols being a complex conjugate of one of said symbols; and

means for grouping said time sequences into a matrix, each time sequence being a row of said matrix.

10. The invention as defined in claim 9 further comprising L means for encoding each of said data substreams prior to symbols of said data substreams being grouped by said means for grouping, so that said encoded data substreams are grouped by said means for grouping.

11. The invention as defined in claim 9 wherein L=4 and said time sequences are arranged according to a matrix, each time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as one of the matrices of the set of matrices consisting of

$$\begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ b_2 & -b_1^* & -b_4 & b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ b_4 & -b_3^* & b_2 & -b_1^* \end{bmatrix}, \begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ -b_2 & b_1^* & b_4 & -b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ -b_4 & b_3^* & -b_2 & b_1^* \end{bmatrix}, \begin{bmatrix} b_1 & -b_2 & b_3 & -b_4 \\ b_2^* & b_1^* & b_4^* & b_3^* \\ b_3 & b_4 & -b_1 & -b_2 \\ b_4^* & -b_3^* & -b_2^* & b_1^* \end{bmatrix}, \text{ and}$$

$$\begin{bmatrix} b_1 & b_2 & b_3 & b_4 \\ b_2^* & -b_1^* & b_4^* & -b_3^* \\ b_3 & -b_4 & -b_1 & b_2 \\ b_4^* & b_3^* & -b_2^* & -b_1^* \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively, and

* indicates complex conjugate.

12. The invention as defined in claim 9 wherein L=4 and said time sequences are spread and arranged according to a matrix, each spread time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as follows:

$$\begin{bmatrix} b_1\overline{c}_1 & b_2^*\overline{c}_2 & b_3\overline{c}_3 & b_4^*\overline{c}_4 \\ b_2\overline{c}_1 & -b_1^*\overline{c}_2 & -b_4\overline{c}_3 & b_3^*\overline{c}_4 \\ b_3\overline{c}_1 & b_4^*\overline{c}_2 & -b_1\overline{c}_3 & -b_2^*\overline{c}_4 \\ b_4\overline{c}_1 & -b_3^*\overline{c}_2 & b_2\overline{c}_3 & -b_1^*\overline{c}_4 \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively;

* indicates complex conjugate; and

$\overline{c}_l$, l=1 .., L are each horizontal vectors of a spreading code, each of said horizontal vectors spans 1 symbol period and contains N chips, where N is the spreading gain.

13. The invention as defined in claim 9 wherein at least one of said derivatives of said symbols is one of the group consisting of: a negative of one of said symbols, a negative of a complex conjugate of one of said symbols, one of said symbols, a symbol developed by encoding at least one sample of at least one of said data substreams, an unencoded sample of at least one of said data substreams.

14. The invention as defined in claim 9 wherein each row of said matrix represents what is transmitted by a respective one of said transmit elements.

15. The invention as defined in claim 9 wherein at least one of said transmit elements is an antenna.

16. A transmitter for use with four transmit elements for transmitting a source bit stream, comprising:

a demultiplexer that divides said source bit stream into L data substreams, $L > 2$;

a space time multiplexer that groups derivatives of symbols derived from of each of said data substreams to form four transmit time sequences, each of said time sequences spanning L symbol periods, at least one of said derivatives of said symbols being a complex conjugate of one of said symbols, said time sequences groups being arranged as a matrix, in which each time sequence is a row of said matrix.

17. The invention as defined in claim 16 further comprising a plurality of radio frequency, each of which converts a respective one of said time sequences groups which it receives as an input from baseband to a radio frequency modulated signal.

18. The invention as defined in claim 16 further comprising at least one encoder interposed between said demultiplexer and said space time multiplexer.

19. The invention as defined in claim 16 wherein said space time multiplexer applies a spreading code to said symbols.

20. The invention as defined in claim 16 wherein at least one of said derivatives of said symbols is one of the group consisting of: a negative of one of said symbols, a negative of a complex conjugate of one of said symbols, one of said symbols, a symbol developed by encoding at least one sample of at least one of said data substreams, an unencoded sample of at least one of said data substreams.

21. The invention as defined in claim 16 wherein each row of said matrix represents what is transmitted by a respective one of said transmit elements.

22. The invention as defined in claim 16 wherein at least one of said transmit elements is an antenna.

23. The invention as defined in claim 16 wherein L=4 and said time sequences are arranged according to a matrix, each time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as one of the matrices of the set of matrices consisting of

$$\begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ b_2 & -b_1^* & -b_4 & b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ b_4 & -b_3^* & b_2 & -b_1^* \end{bmatrix}, \begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ -b_2 & b_1^* & b_4 & -b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ -b_4 & b_3^* & -b_2 & b_1^* \end{bmatrix}, \begin{bmatrix} b_1 & -b_2 & b_3 & -b_4 \\ b_2^* & b_1^* & b_4^* & b_3^* \\ b_3 & b_4 & -b_1 & -b_2 \\ b_4^* & -b_3^* & -b_2^* & b_1^* \end{bmatrix}, \text{ and}$$

$$\begin{bmatrix} b_1 & b_2 & b_3 & b_4 \\ b_2^* & -b_1^* & b_4^* & -b_3^* \\ b_3 & -b_4 & -b_1 & b_2 \\ b_4^* & b_3^* & -b_2^* & -b_1^* \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively, and

* indicates complex conjugate.

24. The invention as defined in claim 16 wherein L=4 and said time sequences are spread and arranged according to a matrix, each spread time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as follows:

$$\begin{bmatrix} b_1\overline{c}_1 & b_2^*\overline{c}_2 & b_3\overline{c}_3 & b_4^*\overline{c}_4 \\ b_2\overline{c}_1 & -b_1^*\overline{c}_2 & -b_4\overline{c}_3 & b_3^*\overline{c}_4 \\ b_3\overline{c}_1 & b_4^*\overline{c}_2 & -b_1\overline{c}_3 & -b_2^*\overline{c}_4 \\ b_4\overline{c}_1 & -b_3^*\overline{c}_2 & b_2\overline{c}_3 & -b_1^*\overline{c}_4 \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively;

* indicates complex conjugate; and

$\overline{c}_l$, l=1 .., L are each horizontal vectors of a spreading code, each of said horizontal vectors spans 1 symbol period and contains N chips, where N is the spreading gain.

25. A transmitter adapted for use with four transmit elements to transmit a source bit stream, comprising:

a demultiplexer that divides said source bit stream into L data substreams, $L > 2$;

L encoders, each of said encoders receiving and encoding one of said data substreams to produce encoded symbols;

a space time multiplexer that groups derivatives of said encoded symbols derived from each of said data substreams to form four transmit time sequences, each of said time sequences spanning L symbol periods, at least one of said derivatives of said symbols being a complex conjugate of one of said symbols, said time sequences groups being arranged as a matrix, in which each time sequence is a row of said matrix.

26. The invention as defined in claim 25 wherein L=4 and said time sequences are arranged according to a matrix, each time sequence being a row of said matrix and being transmitted by a respective one of said transmit elements, said matrix being arranged as follows:

$$\begin{bmatrix} b_1 & b_2^* & b_3 & b_4^* \\ b_2 & -b_1^* & -b_4 & b_3^* \\ b_3 & b_4^* & -b_1 & -b_2^* \\ b_4 & -b_3^* & b_2 & -b_1^* \end{bmatrix}$$

where:

b_1, b_2, b_3, and b_4 are said symbol derivatives from data substreams 1, 2, 3, and 4, respectively, and

* indicates complex conjugate.

27. The invention as defined in claim 25 further comprising a plurality of radio frequency, each of which converts a respective one of said time sequences groups which it receives as an input from baseband to a radio frequency modulated signal.

28. The invention as defined in claim 25 wherein said space time multiplexer applies a spreading code to said symbols.

29. The invention as defined in claim 25 wherein each row of said matrix represents what is transmitted by a respective one of said transmit elements.

30. The invention as defined in claim 25 wherein at least one of said transmit elements is an antenna.

31. A method for use in processing received signals that were transmitted via four transmit elements of a transmitter, said transmitter being adapted to transmit a source bit stream by dividing said source bit stream into L data substreams, $L > 2$ and grouping derivatives of symbols derived from each of said data substreams to form four transmit time sequences, one sequence for each transmit element, each of said time sequences spanning L symbol periods, at least one of said derivatives of said symbols being a complex conjugate of one of said symbols, said method comprising the step of:

developing, from a received signal including versions of said time sequences which have been combined by the channel between said transmit elements and said receiver, reconstructed versions of said symbols derived from each of said data substreams.

32. The invention as defined in claim 31 wherein said developing step further comprises the step of developing reconstructed versions of said groups of derivatives of said symbols.

33. The invention as defined in claim 31 further comprising the step of developing reconstructed versions of said L data substreams from said reconstructed versions of said symbols

34. The invention as defined in claim 31 further comprising the step of multiplexing reconstructed versions of said L data substreams to form a data version of said source bit stream.

35. The invention as defined in claim 31 further comprising the step of developing reconstructed versions of said L data substreams from said reconstructed versions of said symbols by decoding said reconstructed versions of said symbols to produce samples of said reconstructed versions of said L data substreams.

36. The invention as defined in claim 31 wherein said developing step further comprises the step of despreading said received versions of said time sequences.

37. The invention as defined in claim 31 wherein said developing step further comprises the step of subsampling said received versions of said time sequences.

38. The invention as defined in claim 31 wherein said developing step further comprises the step of match filtering derivatives of said received versions of said time sequences.

39. The invention as defined in claim 31 wherein said developing step further comprises the step of decorrelating said received versions of said time sequences.

40. The invention as defined in claim 31 wherein said developing step further comprises performing minimum mean squared error processing.

41. The invention as defined in claim 31 further comprising the steps of:

developing, from a second received signal including versions of said time sequences which have been combined by the channel between said transmit elements and said receiver, second reconstructed versions of said symbols derived from each of said data substreams; and

combining said reconstructed versions and said second reconstructed versions to produce final versions of said symbols.

42. Apparatus for use in processing received signals that were transmitted via four transmit elements of a transmitter, said transmitter being adapted to transmit a source bit stream by dividing said source bit stream into L data substreams, $L > 2$ and grouping derivatives of symbols derived from each of said data substreams to form four transmit time sequences, one sequence for each transmit element, each of said time sequences spanning L symbol periods, at least one of said derivatives of said symbols being a complex conjugate of one of said symbols, said apparatus comprising:

a matrix multiplier for supplying as an output matched filtered signals which are versions of preprocessed signals derived from a received signal which includes versions of said time sequences which have been combined by the channel between said transmit elements and said receiver ; and

a baseband signal processing unit receiving said matched filtered signals as an input and developing therefrom reconstructed versions of said symbols derived from each of said data substreams.

43. The invention as defined in claim 42 wherein said receiver is a minimum mean square error receiver.

44. The invention as defined in claim 42 wherein said matrix multiplier multiplies from the left an L by 1 vertical vector $\mathbf{d}$ formed by versions of said preprocessed signals derived from said received signal by a matrix $\mathbf{H}^{\dagger}$ to produce a new L by 1 vertical vector $\mathbf{f}$ so that $\mathbf{f} = \mathbf{H}^{\dagger}\mathbf{d}$ where $\dagger$ denotes complex conjugate.

45. The invention as defined in claim 44 wherein $L = 4$, and $\mathbf{H}$ is the following matrix

$$\begin{bmatrix} h_1 & h_2 & h_3 & h_4 \\ -h_2^* & h_1^* & -h_4^* & h_3^* \\ -h_3 & h_4 & h_1 & -h_2 \\ -h_4^* & -h_3^* & h_2^* & h_1^* \end{bmatrix}$$

where h_i is the complex channel coefficient from the i^{th} transmit element to said receiver and all channels are flat faded channels.

46. The invention as defined in claim 44 wherein at least one element of said vertical vector **d** is formed by versions of said preprocessed signals derived from said received signal that has had the complex conjugate of at least one element thereof substituted for said element.

47. The invention as defined in claim 42 wherein said baseband signal processing unit multiplies a specified matrix **W** from the left by a vertical vector **f** made up of said matched filtered outputs supplied by said matrix multiplier to produce a new L by 1 vertical vector **r**, so that $\mathbf{r} = \mathbf{Wf}$.

48. The invention as defined in claim 47 wherein matrix $\mathbf{W}=\mathbf{K}^{-1}$, where $\mathbf{K}= \mathbf{H}^{\dagger}\ \mathbf{H}$.

49. The invention as defined in claim 48 wherein L=4 and said matrix multiplication is performed in two portions, the first portion using the first and third element of vertical vector **f** and the second portion using the fourth and second element of vertical vector **f**, specifically in that order and in which a 2 x 2 matrix employed for the multiplication from the left for both portions is developed by deriving 2 x 2 matrix $\mathbf{K}'$ through deleting the second and fourth rows and columns of 4 x 4 matrix **K** where $\mathbf{K} = \mathbf{H}^{\dagger}\mathbf{H}$ and 2 x 2 matrix $\mathbf{W}' = \mathbf{K}'^{-1}$.

50. The invention as defined in claim 47 wherein matrix $\mathbf{W}=\mathbf{K}^{\dagger}(\mathbf{K}\ \mathbf{K}^{\dagger}+\lambda\ \mathbf{K}\ )^{-1}$, where λ is a real scalar.

51. The invention as defined in claim 50 wherein λ is equal to σ_n^2 / σ_b^2 where σ_n^2 is the channel noise variance and σ_b^2 is the variance of each symbol b_i, where i= 1 .. L.

52. The invention as defined in claim 50 wherein L=4 and said matrix multiplication is performed in two portions, the first portion using the first and third element of vertical vector **f** and the second portion using the fourth and second element of vertical vector **f**, specifically in that order and in which a 2 x 2 matrix employed for the multiplication from the left for both portions is developed by deriving 2 x 2 matrix **K'** through deleting the second and fourth rows and columns of 4 x 4 matrix **K** where $\mathbf{K} = \mathbf{H}^{\dagger}\mathbf{H}$ and 2 x 2 matrix $\mathbf{W'} = \mathbf{K'}^{\dagger}(\mathbf{K'}\,\mathbf{K'}^{\dagger} + \lambda\,\mathbf{K'})^{-1}$.

53. The invention as defined in claim 42 further comprising L despreaders for developing said versions of said preprocessed signals from said received signal.

54. The invention as defined in claim 42 further comprising a demultiplexer for developing said versions of said preprocessed signals from said received signal.

55. The invention as defined in claim 42 further comprising a selective conjugator for developing said versions of said preprocessed signals derived from said received signal by conjugating at least one element of despread versions of said preprocessed signals derived from said received signal.

56. The invention as defined in claim 42 further comprising a selective conjugator for developing said versions of said preprocessed signals derived from said received signal by conjugating at least one element of subsampled versions of said preprocessed signals derived from said received signal.

57. The invention as defined in claim 42 further comprising L decoders, each of said decoders receiving as an input reconstructed versions of said symbols derived from a respective one of said data substreams and developing therefrom a reconstructed version of said one of said data substreams.

58. The invention as defined in claim 42 further comprising *L* decoders, each of said decoders receiving as an input reconstructed versions of said symbols derived from a respective one of said data substreams and developing therefrom a reconstructed version of said one of said data substreams.

59. The invention as defined in claim 58 further comprising a multiplexer which receives each reconstructed version of said data substreams from said decoders and develops therefrom a reconstructed version of said source bit stream.

60. The invention as defined in claim 42 further comprising:

a second matrix multiplier for supplying as an output second matched filtered signals which are second versions of preprocessed signals derived from a second received signal which includes versions of said time sequences which have been combined by a second channel between said transmit elements and said receiver ; and

a second baseband signal processing unit receiving said second matched filtered signals as an input and developing therefrom second reconstructed versions of said symbols derived from each of said data substreams; and

a combiner for combining said reconstructed versions of said symbols and said second reconstructed versions of said symbols.